ECOLOGICAL STUDY
OF
DEL REY LAGOON

JUNE 1972

FOR

BOARD OF RECREATION AND PARK COMMISSIONERS

OF

CITY OF LOS ANGELES

PREPARED BY

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June 1972
File No. 271-0

The Honorable Board of Recreation
and Park Commissioners
City of Los Angeles
250 East First Street
Los Angeles, California 90012

ATTENTION: John C. Horan, Acting Secretary.

SUBJECT: Report - Ecological Study of Del Rey Lagoon.

Gentlemen:

We are pleased to submit the subject report containing our evaluation and recommendation of methods to obtain at Del Rey Lagoon a full, clear and continuous body of water with minimum ecological displacement, for recreational purposes. The report also presents the information and data upon which the recommendations are based.

We shall be pleased to receive your comments and answer any questions. Thank you for this opportunity to be of service.

Respectfully submitted,

RALPH STONE AND COMPANY, INC.

Ralph Stone

Ralph Stone, President

RS:ml

Enclosure

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SUMMARY

To determine feasibile methods and their costs for maintaining Del Rey Lagoon as a full, clear and continuous body of water with minimum ecological displacement for recreational purposes, studies and investigations were made from January through April 1972. Del Rey Lagoon is a modified shallow water reservoir; it is a developed lagoon that has been improved by man and does not support forms of life of the diversity and densities usually found in natural estuarine lagoons or marshes. The basin was designed as a decorative pond for recreation such as boating, rather than as a natural swampy lagoon restricted for a wild life preserve.

Results

During the four month study period the lagoon water had a very low turbidity (about 2 JTU) which made bottom visible. Plant and animal life existed, but was very limited. Some vegetation grew along the shore; various birds (mostly geese) coots and ducks inhabited the area; aquatic life was sparce, few fish were observed; the bottom sediments were inhabited by snails, ghost shrimp, mud crab, barnacles, and few other fauna and flora. The lagoon water did not contain toxic substances or nutrients in unusual concentrations. However, upon inflow of nutrients, algae could proliferate during warm periods.

The lagoon bottom consists variously of mixtures of black to brown clay, silt and sand. The black color indicated the presence of organic materials; however, only about 5.3 percent of the total solids in the benthic samples were of organic nature and these samples had no (or only very slight) odors. The dissolved oxygen concentration near the bottom was about 8.0 mg/l.

There are few currents within the lagoon. The water circulation which exists occurs primarily during prolonged periods of strong winds.

During the study period, the lagoon was in suitable condition for the designated recreational activities. The water was relatively clear and contained few weeds. The clean lagoon exists probably in part due to the physical maintenance of the area, the chemical treatments and flushings by the Department of Recreation and Parks' staff, and in part due to cool seasonal weather. The primary challenge is to continue to maintain the lagoon water quality throughout the year, and prevent the recurrence of excessive weed growth and algal blooms.

RECOMMENDATIONS

To maintain a full, clean continuous body of lagoon water suitable for recreation, we recommend the following actions:

1. Automatic, periodic lagoon flushing to remove water nutrients and to maintain salinity for prevention of weed growth. Examination of the 1972 Tide Tables reveals 9 months have from 3 to 11 days during which a low tide and a high tide occur between 7:00 pm and the following 7:00 am and the high tide is 5.0 ft M.S.L. or greater. Only August, September and October do not have tides meeting these criteria, but these three months can meet the elevation criteria if the time for the high tide is extended to 10:30 am. Utilizing the water elevation differences provided by the tides, automated control of existing gates could provide very adequate flushing action. The automation would consist of a float switch over-ridden by a cam operated controller, with the cam cut to provide for opening the gate only on those days when the tide is at sufficient recorded elevation and clarity during the desired interval. An automatic turbidimeter can be used to measure and record turbidity. The control would have a manual over-ride to permit discontinuing flushing for one cycle during "red tide" or other unfavorable conditions. (See also Recommendation 5 .)

2. Vegetation control by yearly application of Karmex (60 lbs/acre) or other suitable herbicide. This should be employed during the early growing stage to those areas of the lagoon showing water weed development. (See also Recommendation 5.)

3. Algae control by applications of a copper compound such as copper citrate or Cutrine. The latter has been used by the Department of Recreation and Parks. The algicide should be applied when algal content builds up to cause observable tubidities.

4. Inhibition of weed and algal growth, by preventing the inflow of nutrients. This involves:

a) Removal of land vegetation below the high tide water line. (This was being accomplished at the picnic grounds near the south end of the lagoon during the latter part of the study period.)

b) Eliminating of land area storm drainage inflow.

c) Efforts to control pollution by users of the lagoon.

d) Replenishing lagoon water with only clean, pollution-free Ballona Creek water of ocean origin. When the red tide condition prevails, or during rain runoff periods there should not be any interchange of flushing of the lagoon with Ballona Creek water which is then partially polluted.

e) Periodic annual draining of the lagoon and removal of litter and detritus.

f) Keep irrigation drainage out of the lagoon.

5. A possible alternative method to replace flushing and chemical vegetation control (Recommendations 1 and 2) is biological vegetation control. Sea urchins are known to thrive on certain aquatic plants including Ruppia (and kelp). The lagoon could be stocked with the urchins in sufficient number to suppress the development of Ruppia to an extent which would not interfere with the recreational uses of the lagoon. Initial laboratory and field tests would be needed to confirm the feasibility of this approach and establish the optimum urchin population density.

I. INTRODUCTION

A. Background

Ecological studies in the Del Rey Lagoon for the City of Los Angeles Board of Recreation and Park Commissioners were conducted from January through April of 1972. The purpose of the studies was to obtain the necessary data and other information for preparation of a preliminary report and cost estimates for improvements to obtain a full, clean and continuous body of water with minimum ecological displacement for recreational purposes. The work completed consisted of lagoon ecology studies, bottom topographic surveying, bottom jettings and samplings, sediment sampling, current and water column dissolved oxygen measurements, and water and plankton sampling.

B. Objectives

The objectives of these studies were to: determine the basic ecology of the lagoon prior to any changes; present alternative methods of achieving a clean recreational water body with minimum ecological displacement; estimate the costs of these methods; establish conclusions and recommend a course of action.

II. DEL REY LAGOON INVESTIGATIONS

A. Survey Scope

During the winter and spring of 1972, field surveys were performed at Del Rey Lagoon as follows:

January 3-4:	Water and benthic samples; oceanographic and bathymetric survey; ecological and physical characteristics investigations.
January 26:	Lagoon drained and benthic and core samples taken.
February 23-24:	Comprehensive ecological survey.
March 7:	Water samples; oceanographic survey; ecological observations.
April 5:	Water samples; oceanographic survey; ecological observations.

The survey stations were selected from a grid established over the lagoon's water area, consisting of eight primary stations along the longitudinal center line, and twenty-four secondary stations. The locations of these stations are shown in Figure 1.

Water and benthic samples were obtained and analyzed by the staff of Ralph Stone and Company, Inc. The comprehensive ecological survey was made by James Vallee, Ph.D. Oceanographic sampling and surveying was also performed by the staff of Ralph Stone and Company, Inc. using company-owned equipment. The dory used in all sampling was provided and crewed by City of Los Angeles Lifeguards. A bathymetric survey was made and a contour map of the lagoon basin was constructed by the staff of Ralph Stone and Company, Inc. and is attached as Appendix I.

A complete tabulation of the data obtained during the study period is provided in Tables 1 through 8. General views of the area are shown in Photographs 1 through 8.

B. Ecological Survey

The ecological investigation was directed toward observation, where possible, of the density and diversity of animal life and marine vegetation. The ecological data was used in evaluating the environmental effects of any new dredging, construction, and water and/or weed treatment on the beneficial uses of the lagoon waters and on the areal marine environment. Ecological observations were made during performance of other routine sampling and samples of representative conditions were taken.

Plankton samples were taken by towing a plankton net behind the dory approximately three feet below the surface over a measured distance, usually 1,100 feet along the

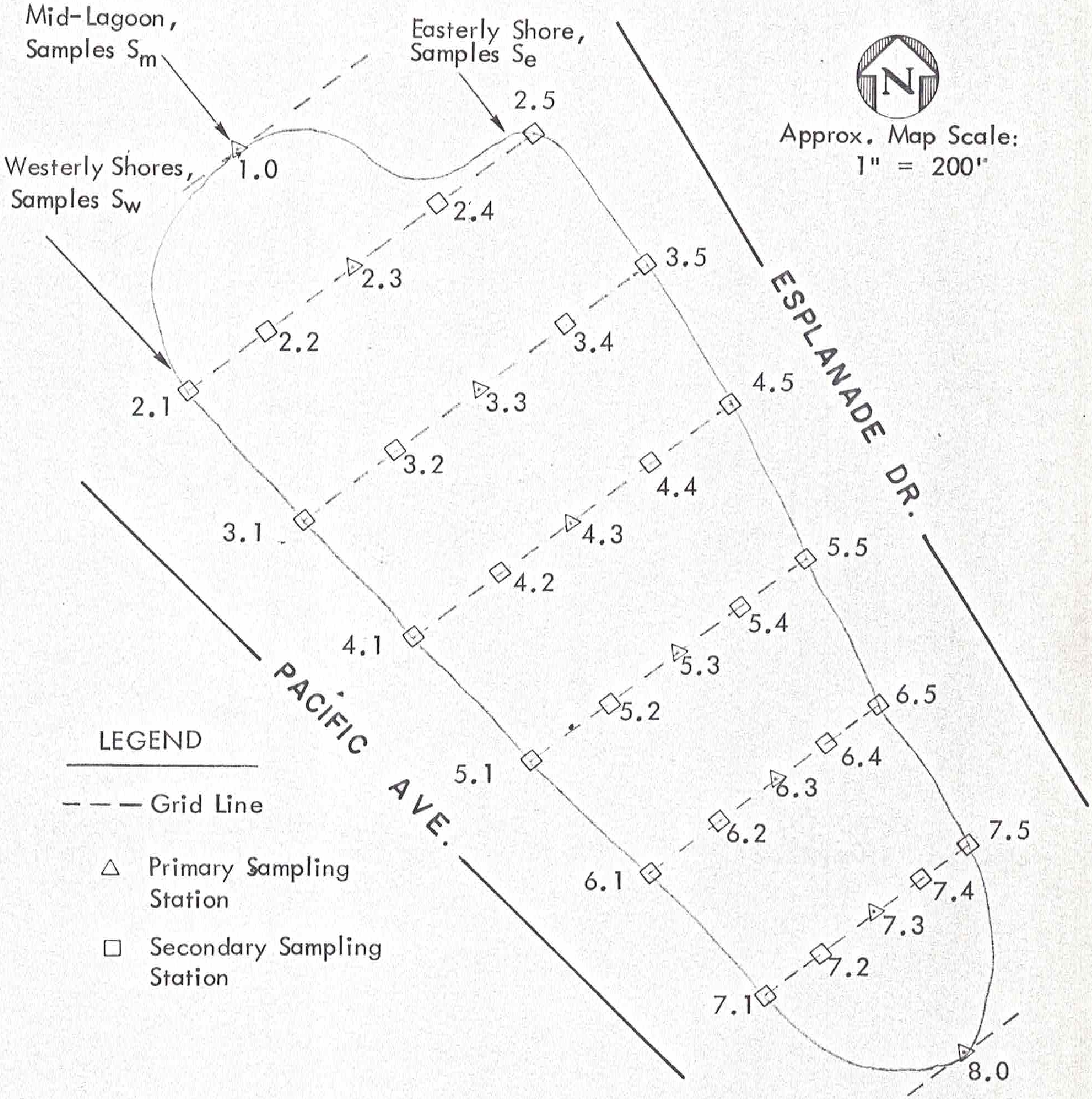

FIGURE 1

DEL REY LAGOON
SAMPLING STATIONS

CITY OF LOS ANGELES
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easterly and westerly shores and the approximate longitudinal center line. The samples were preserved in a formalin solution and returned to our laboratory for analysis of productivity from the volume of water screened to obtain such a sample.

Algal productivity was found to be very low on all three sampling dates; some plankton were present, but the highest concentration was only 0.008 mg/l on April 5, 1972. The results of the algal productivity analyzed are presented in Table 1. These concentrations are based on the weight of plankton retained on the net in the volume of water through which the net was dragged.

A comprehensive ecological survey of the drained lagoon was made on February 23 and 24, 1972. The flora consisted primarily of sea felt (Enteromorpha). Although much of this algae was washed out when the lagoon was drained, approximately 15 percent of the bottom was still covered with algal mats up to two inches thick. Scattered Ruppia seedlings (two inches tall) were seen along the western shoreline of the lagoon. Near the south end of the lagoon, Ruppia were more abundant (five per square foot), and along the eastern side of the lagoon their seedlings were seen in population densities of up to 200 per square foot.

The epifauna consisted primarily of barnacles (Balanus tintinnabulum) which occurred in thick clusters on most of the rocks in the lagoon. A few serpulid worms (calcareous tube worms) were also seen on the rocks. Two live bubble shells (Bulla gouldiana) and three solid nudibranchs (Aeolidiella) were seen near the eastern side of the lagoon.

The infauna was sampled at 10 stations (1.0, 2.2, 2.4, 3.3, 4.2, 4.4, 5.3, 6.2, 6.4, and 7.3) throughout the lagoon. At each station an area of one square yard was sampled to a depth of one foot and 1/4 ft^3 of this was screened to obtain the smaller members of the infauna.

The most conspicuous components of these samples were the shells of dead smooth chiones (Chione fluctifraga), California jackknife clams (Tagelus californianus), bent nose clams (Macoma nasuta), and California horn snails (Cerithidea californica). Live bivalves were seen only at one station (2.4 near the tide gate) where six small (1/4 inch) smooth chiones were obtained from the 1/4 ft^3 screening sample. Several burrows of the mud crab (Hemigrapsus oregonensis) were noted in the west-central region of the lagoon and two live specimens were seen here. Burrows of the ghost shrimp (Callianassa californiensis) were seen at stations at the south end of the lagoon (approximately two entrances per square yard), and live specimens were obtained from the sampled area at three of these stations.

The southern one-third of the lagoon was inhabited by large numbers of polychaete worms (Armandia bioculata, Polydora) with population densities of up to 500 per square foot. These worms were also seen near the tide gate in population densities of about 300 per square foot. Seven specimens of a small (1/4"), primitive, shrimp-like crustacean, Epinabalia, were seen near the south end of the lagoon.

TABLE 1

ALGAL PRODUCTIVITY

mg/l*

Location	1/3/72	3/7/72	4/5/72
Easterly Shore	.004	.002	.008
Longitudinal Center Line	.004	-	.004
Westerly Shore	.038	-	.0055

*Based on weight of plankton retained on net in volume through which the net was dragged.

Resident water birds seen in the lagoon included approximately 10 mallards (Anas platyrhynchos) and 50 coots (Fulica americana), as well as a few domestic ducks and geese. Mrs. Barhydt has observed migratory birds described in Appendix 1.

In summary, there was a conspicuous lack of bivalve mollusks (clams, etc.) in the lagoon; an abundance of sea felt (Enteromorpha), barnacles (Balanus tintinnabulum), and polychaete worms; very few gastropod mollusks (snails, etc.); and although mud crabs (Hemigrapsus oregonensis) and ghost shrimp (Callianassa californiensis) did occur in some parts of the lagoon, their population densities were about 1/100th that of a natural lagoon. Ruppia seedlings were abundant at some stations. The infauna and biota observations are summarized in Table 2.

The ecological survey indicates the comparatively limited existing plant and animal life, which is to be expected in a man-made lagoon in contrast to a natural ocean-connected body of water. The lagoon resident population of birds is supplemented by migratory birds that have been previously noted. This circumstance makes the lagoon well-suited for the projected boating use without impairment of important ecological systems, providing only that weed growths and plankton proliferations are suppressed by methods such as recommended in this report.

C. Lagoon Currents

The water and air currents were measured at Stations 2.3 through 7.3 at two-foot intervals through the air and water profile. Air currents were also measured at stations 1.0 and 8.0; at these stations the lagoon is too shallow for water current measurements. Current speed was measured with a Savonius Rotor current transducer and current speed indicator with a magnetic compass direction transducer. The equipment was lowered by hand from the dory and readings were taken from direct readout meters on board. Dorry movement on station slightly affected current readings. An alternate method of determining the existence of currents was to drop the ash from a cigarette into the water and then observe its descent. A straight descent indicated there was no measurable current. The current measurements are tabulated in Table 3 and shown graphically in Figures 2, 3 and 4.

On January 3 and April 5, 1972, no appreciable currents were detected in the lagoon, although on April 5 a measureable, steady, slight breeze was blowing in a northerly direction. (See Figures 2 and 4 and Table 3.) On March 7, 1972, slight westerly currents in the northern portion of the lagoon at all depths were detected resulting possibly from a gentle breeze blowing in a generally northerly direction. (See Figure 3 and Table 3.) However, such incidental currents cannot be relied upon for sufficient water circulation to be effective in suppressing weed growth. Only during prolonged periods with strong winds or while there is flushing, can effective water circulation in the lagoon be expected.

D. Water Quality Characteristics

Water samples were taken with a corked bottle attached to a measurement pole at eight separate Stations and each of three levels of depth: bottom, middle and surface. The

TABLE 2

INFAUNA AND BIOTA OBSERVATIONS

Station *	Infauna and Biota
1.0	Shells of dead Chione fluctifraga, Tagelus californianus, Macoma nasuta and Cerithidea californica.
2.2	Shells of dead Tagelus californianus and Macoma nasuta.
2.4	Shells of dead Mytilus edulis and Chione fluctifraga. Polychaete worms(Armandia bioculata, Polydora) - 300 per ft^2.
3.3	Shells of dead Chione fluctifraga, Tagelus, californianus, Macoma nasuta and Cerithidea californica.
4.2	Shells of dead Tagelus californianus and Macoma nasuta. Several Hemigrapsus burrows were seen here, along with one live specimen.
4.4	Shells of dead Chione fluctifraga, Tagelus californianus, Macoma nasuta, and Cerithidea californica. Live Ruppia maritina (200 two inch seedlings per square foot). Callianassa burrows (Two entrances per square yard).
5.3	Shells of dead Tagelus californianus, Macoma nasuta, and Chione fluctifraga. Several burrows of Hemigrapsus. Callianassa burrows (two entrances per square yard); two live Callianassa californiensis were seen here.
6.2	Shells of dead Macoma nasuta and Chione fluctifraga. Callianassa burrows (two entrances per square yard); one live Callianassa californiensis was seen here. Several burrows of Hemigrapsus; one live Hemigrapsus oregonensis. Polychaete worms (Armandia bioculata, Polydora) - 500 per square foot.
6.4	Shells of dead Macoma nasuta, Tagelus californianus. Callianassa burrows (two entrances per square yard), Polychaete worms (Armandia bioculata, Polydora)- 500 per square foot. Ruppia maritina - 200 two inch seedlings per square foot.
7.3	Callianassa burrows (two entrances per square yard). On live Callianassa californiensis, seven Epinabalia, polychaete worms (Ophelia?) - 200 per square foot. Ruppia seedlings (5 two inch seedlings per square foot

* For station locations, see Figure 1.

TABLE 3

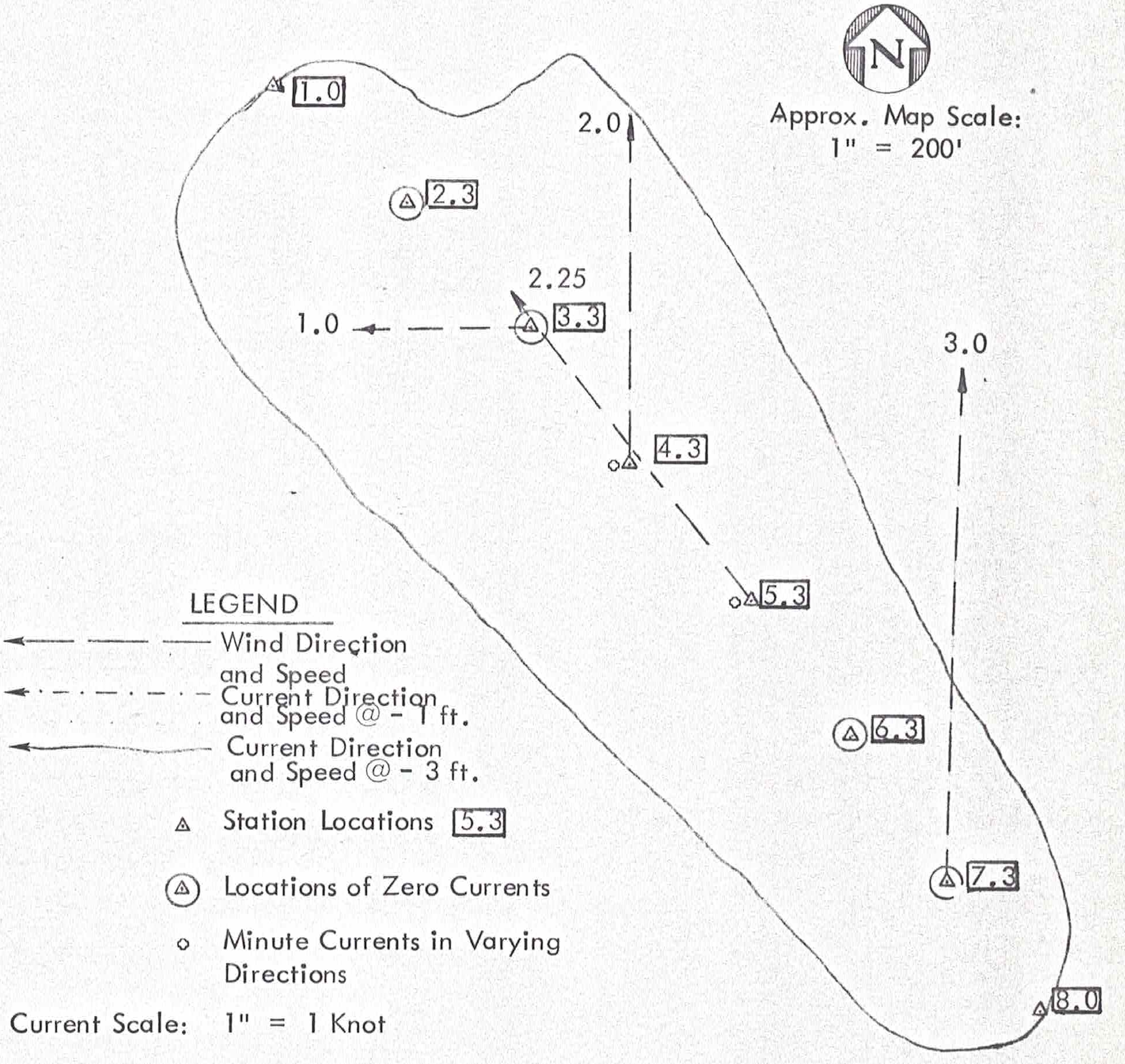
LAGOON CURRENTS; VELOCITY AND DIRECTION

1972	Station	1.0		2.3		3.3		4.3		5.3		6.3		7.3		8.0	
Date	Depth[a]	V	D	V	D	V	D	V	D	V	D	V	D	V	D	V	D
1/3	Air	-	-	-	-	1±	270	0-2	0-360	2.25	320	0	-	3.0	360	-	-
	-1	-	-	0	-	0	-	.13	0-360	0	-	0	-	0	-	-	-
	-3	-	-	0	-	0	-	.15	0-360	.05	135	0	-	0	-	-	-
	-5	-	-	0	-	0	-	0	0-360	0	-	0	-	0	-	-	-
3/7	Air	.75	315	.70	355	1.25	355	1.25	330	1.75	355	1.0	355	.95	315	.75	315
	-1	-	-	.50	265	.25	270	.20	265	0.0	-	0	-	0	-	-	-
	-3	-	-	.25	265	.25	275	.75	265	0.0	-	0	-	0	-	-	-
4/5	Air	4.0	360	.69	360	1.5	360	0	0	2.50	360	2.5	360	1.50	360	2.25	180
	-1	-	-	0	-	-	-	.13	195	-	-	.2	195	0	0	-	-
	-2	-	-	0	-	-	-	-	-	0	0	-	-	-	-	-	-
	-4	-	-	0	-	.05	270	0	0	0	0	0	0	0	0	-	-

LEGEND: V = Velocity in Knots

D = Direction - degrees azimuth

a = Depth in feet below water surface at time of measurement.



N
Approx. Map Scale:
1" = 200'
1.0
2.0
2.3
2.25
1.0
3.3
3.0
4.3
5.3
6.3
7.3
8.0
LEGEND
Wind Direction and Speed
Current Direction and Speed @ - 1 ft.
Current Direction and Speed @ - 3 ft.
Station Locations 5.3
Locations of Zero Currents
Minute Currents in Varying Directions
Current Scale: 1" = 1 Knot

FIGURE 2

CURRENT VELOCITIES AND DIRECTIONS
JANUARY 3, 1972

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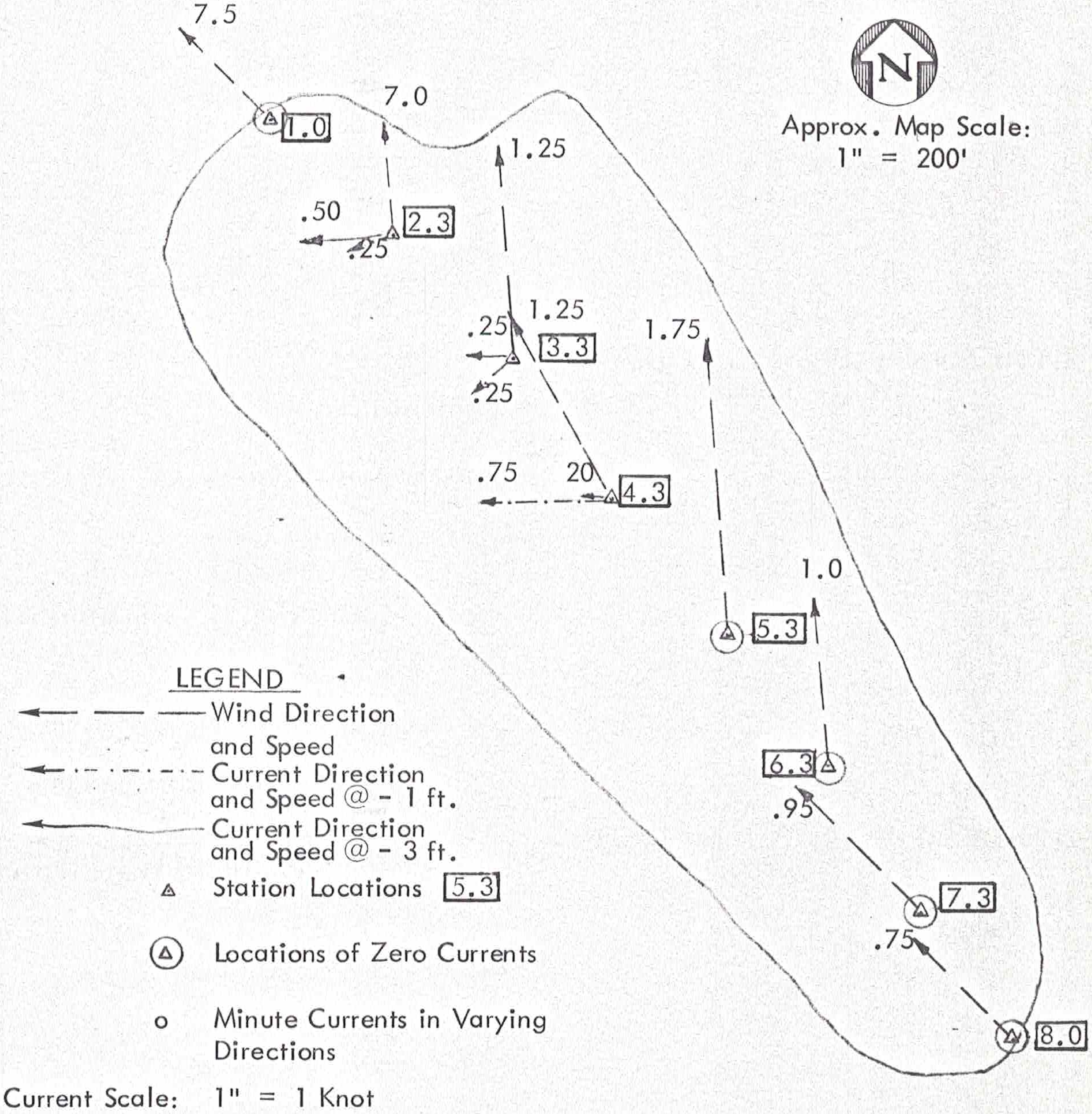
7.5
7.0
1.0
N
Approx. Map Scale:
1" = 200'
1.25
.50
2.3
.25
1.25
.25
3.3
.25
1.75
.75
20
4.3
1.0
5.3
6.3
.95
7.3
.75
8.0
LEGEND
Wind Direction and Speed
Current Direction and Speed @ - 1 ft.
Current Direction and Speed @ - 3 ft.
Station Locations
5.3
Locations of Zero Currents
o
Minute Currents in Varying Directions
Current Scale: 1" = 1 Knot

FIGURE 3

CURRENT VELOCITIES AND DIRECTIONS
MARCH 7, 1972

CITY OF LOS ANGELES
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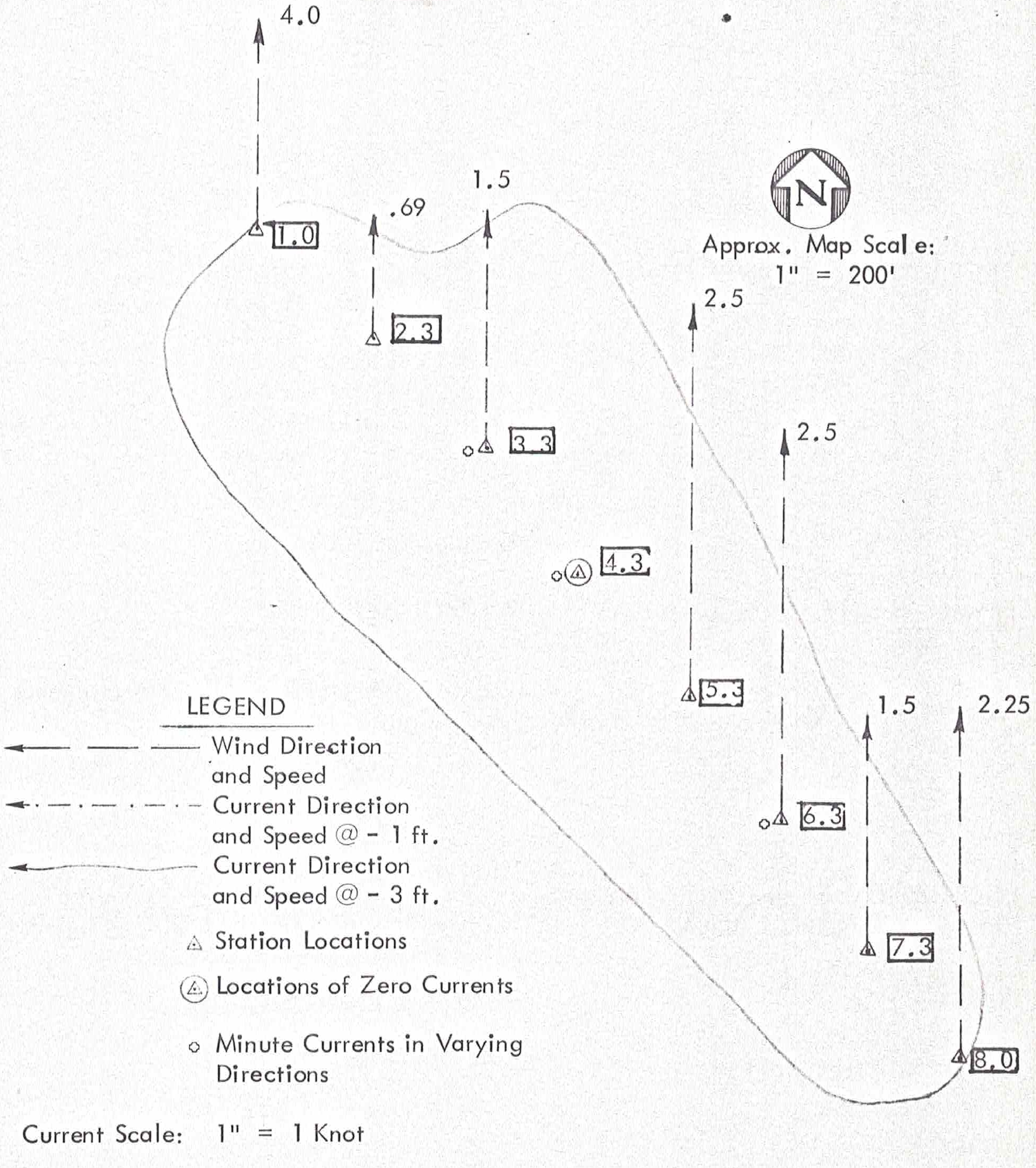
4.0
1.0
.69
2.3
1.5
3.3
N
Approx. Map Scale:
1" = 200'
2.5
2.5
4.3
5.3
6.3
1.5
2.25
7.3
8.0
LEGEND
Wind Direction and Speed
Current Direction and Speed @ - 1 ft.
Current Direction and Speed @ - 3 ft.
Station Locations
Locations of Zero Currents
Minute Currents in Varying Directions
Current Scale: 1" = 1 Knot

FIGURE 4

CURRENT VELOCITIES AND DIRECTIONS
APRIL 5, 1972

CITY OF LOS ANGELES
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water samples were analyzed as specified in Standard Methods, 13th Edition (1971) for: pH, electrical conductivity, laboratory temperature, and turbidity. Selected individual samples were analyzed for chloride (Cl) total phosphate (PO_4), nitrate (NO_3), copper (Cu), total dissolved solids (TDS) and five-day biochemical oxygen demand (BOD_5). A composite was made up of the three samples from each station and each composite was analyzed for chloride, total phosphate and nitrate. Additional individual samples were composited for each station from all the sampling periods and analyzed for lead, mercury and arsenic.

Dissolved oxygen was profiled in two to three foot intervals at Stations 2.3 through 7.3. The samples were analyzed in the field shortly after collection with a Beckman laboratory-type analyzer. Temperatures of the same samples were measured immediately after collection with a mercury-tube thermometer. The results are presented in Table 4. (The Martek Model DOA dissolved oxygen and thermal sensory monitoring system with which these two determinations would ordinarily be made in-situ, was in need of repairs at the time of this survey.)

Transparency measurements in-situ were to be taken by lowering a Secchi Disc to a depth at which it is no longer visible; the depth indicates the transparency. However, the lagoon bottom was readily visible from the dory on all field survey dates, and consequently no Secchi readings were taken.

The water quality characteristics are presented in Table 5 (Chemical Characteristics) and Table 6 (Physical Characteristics). The quality of this water is as expected for this type of water body. No unusual nutrient, toxicity, or other pollution conditions were found.

E. Survey of Benthic Conditions

The bottom elevations of the lagoon were determined by field surveying from which a bathymetric map, Drawing No. 1, was prepared.

Lagoon benthic samples were to be taken in-situ by the "grab" method using an Ekman-Birge bottom dredge. However, the lagoon bottom was too hard and dredging from the dory too awkard for use of this equipment. Sediment core samples were obtained at various stations with the aid of a Phleger Corer. The core samples were retained in a clear plastic tube to aid in sample core inspection and identification. The core samples were analyzed for pH and conductivity; odor was noted; and soil type was determined visually.

The results of the benthic investigation are shown in Tables 7 and 8. The sediment consisted of various mixtures of black to brown clay, silt and sand, and some rocks and shell fragments. The black color indicates the presence of organic material. However, none or only very slight odors were noted. Apparently decomposition had largely been completed. This was also confirmed by the high dissolved oxygen concentration even at the bottom of the lagoon (about 8 mg/l), and by the low percentage of organic matter

TABLE 4

DISSOLVED OXYGEN AND TEMPERATURE PROFILES

Station		1.0		2.3		3.3		4.3		5.3		6.3		7.3		8.0	
Date[a]	Depth[b] ft.	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO
1/3	Air	-	-	-	-	13.5	-	-	-	17.0	-	18.0	-	14.0	-	-	-
	0	-	-	12.0	7.7	11.5	-	11.7	8.1	12.0	7.6	12.0	7.65	11.7	7.9	-	-
	2	-	-	11.7	7.6	-	-	11.3	8.1	12.0	7.5	12.0	7.7	11.5	7.9	-	-
	4	-	-	-	-	-	-	11.0	8.0	11.5	7.5	11.8	7.6	11.4	7.9	-	-
	5	-	-	11.2	7.6	-	-	11.0	8.0	11.5	7.5	-	-	11.4	7.8	-	-
	6	-	-	-	-	-	-	-	-	-	-	11.5	7.6	-	-	-	-
3/7	Air	16	-	16	-	16	-	16	-	16	-	16	-	16	-	16	-
	Surface	17	7.4	17	7.6	17	7.6	17	7.6	17	7.6	17	7.5	17	7.4	17	7.4
	Mid-depth	-	-	17	7.9	17	7.9	17	8.0	17	8.0	17	7.9	17	7.7	-	-
	Button	-	-	17	7.9	17	8.0	17	8.0	17	7.8	17	-	17	7.7	-	-
4/5	Air	17	-	17	-	18	-	18	-	18	-	18	-	19	-	19	-
	Surface	21	8.1	21	8.3	21	8.2	21	8.2	21	8.2	21	8.1	21	8.2	21	8.2
	Mid-depth	-	-	21	8.4	21	8.6	21	8.3	21	8.2	21	8.4	21	8.4	-	-
	Bottom	-	-	21	8.4	21	8.4	21	8.5	21	8.4	21	8.1	21	8.2	-	-

LEGEND: Temp. = Temperature in °C

DO = Dissolved Oxygen, mg/l

a = 1972

b = Depth in feet below water surface at time of measurement

TABLE 5

CHEMICAL ANALYSES

Station			1.0	2.3	3.3	4.3	5.3	6.3	7.3	8.0
Parameter - mg/l		Date[a]								
BOD_5	Surface	1/3	-	5	-	-	5	65	-	-
		3/7	-	0	-	0	-	15	-	-
		4/5	-	18	-	-	-	0	-	-
	Mid-depth	1/3	-	-	-	-	-	145	-	-
		3/7	-	0	-	0	-	0	-	-
		4/5	-	0	-	-	-	0	-	-
	Bottom	1/3	30[b]	-	-	-	0	15	-	-
		3/7	-	0	-	5	-	0	-	-
		4/5	-	0	-	0	-	0	-	-
NO_4		1/3	0.50	0.47	0.50	0.47	0.50	0.47	0.50	0.50
PO_4		1/3	0.40	0.50	0.30	0.10	0.20	0.10	0.40	0.10
Cu		1/3	0.11	0.12	0.10	0.07	0.06	0.06	0.10	0.07
Cl		1/3	18,270	-	-	-	18,155	-	-	18,725
Cl		4/5	-	-	-	-	19,100	-	-	-
Pb		1/3	-	0.01	-	0.01	-	0.01	-	-
Hg		1/3	-	<0.01	-	<0.01	-	<0.01	-	-
As		1/3	-	<0.15	-	<0.10	-	<0.10	-	-

[a] 1972

[b] Collected near outlet when lagoon was almost empty.

Note: Samples are composites in equal portions of subsamples taken at surface, mid-depth and bottom of each station.

TABLE 6

PHYSICAL ANALYSES

Parameter	Station	1.0	2.3			3.3			4.3			5.3			6.3			7.3			8.0
	Date[a]	S[b]	B[b]	M[b]	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	S
pH	1/3	7.5	7.4	7.5	7.5	7.5	7.4	7.5	7.5	7.4	7.5	7.5	7.4	7.5	7.5	7.5	7.4	7.5	7.5	7.5	7.5
	3/1	7.5	7.4	7.3	7.4	7.4	7.4	7.4	7.4	7.5	7.5	7.5	7.5	7.5	7.4	7.5	7.4	7.1	7.2	7.2	7.3
	4/5	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Turbidity JTU	1/3	3.0	4.0	2.5	1.5	2.5	3.0	3.0	2.0	2.0	2.0	3.5	2.5	2.0	1.5	1.5	2.0	1.5	1.5	1.5	2.5
	3/1	2.5	3.0	3.0	2.5	3.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.5	3.0	2.0	2.5	3.0	2.5
	4/5	1.5	1.0	1.2	1.2	1.1	1.2	1.2	1.1	1.2	1.0	1.2	1.2	1.2	1.0	1.2	1.0	1.1	1.2	1.1	1.2
Electrical Conductivity mhos/cmx 10^3	1/3	45	46	46	46	47	46	46	49	50	49	47	49	51	49	50	49	48	46	47	48
	3/7	45	44	43	44	43	43	43	44	43	44	42	44	42	43	45	44	42	43	45	41
	4/5	49	49	49	50	49	49	49	49	49	49	50	49	50	49	49	50	50	49	49	50
Temperature °F	1/3	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
	3/7	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63
	4/5	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70

[a] 1972

[b] S = Surface
M = Mid-depth
B = Bottom

TABLE 7 - BENTHIC SURVEY

Sample Location		pH	Conductivity μmhos/cm	Odor	Lagoon Benthic Characteristics
1.0	S	8.95	2400	Slight	Black clay and silt; some sand; several small rocks.
2.3	S_e	8.51	2300	None	Black clay; medium sand; shell fragments
	S_m S_m (surface)	8.0	4400	No particular odor	Black very fine silt and clay; very few sand particles.
	S_w	8.9	2500	None	Black clay and silt; no sand.
3.3	S_e	8.21	1800	None	Medium brown sand fine to medium particles; some clay; several shell fragments.
	S_w	8.3	2200	None	Black clay with some sand and several small rocks.
4.3	S_e	7.75	2100	None	Medium brown sand with some clay; fine to medium sand particles.
	S_m S_w	8.4	2100	Slight odor of marine decay	Dark brown sand and clay; fine to medium sand particles; several small stones.
5.3	S_e	8.3	1900	Very slight	Brown and black clay; some sand; several small rocks.
	S_w	8.45	2200	Very slight	Brown sand with black clay and silt; large stones; many small stones.
6.3	S_e	8.2	2100	None	Black sand and clay; fine to medium particles.
	S_m S_w	8.5	1600	Slight odor of drying marine organisms and vegetation	Medium brown sand fine to medium particles; some black clay; several small rocks, piece of broken glass.
7.3	S_e	7.8	1800	None	Medium brown sand; fine to coarse particles; some black clay; small brown worm,

Continued

TABLE 7 - BENTHIC SURVEY (CONT.)

Sample Location		pH	Conductivity mhos/cm	Odor	Lagoon Benthic Characteristics
7.3	S_m S_w	8.3	1900	None	Light brown sand, fine to medium particles; very little silt or clay; several small rocks.
8.0		7.6	2300	None	Light brown sand fine to medium coarse particles; several small lumps of black clay

LEGEND: S = Sample

S_e = Sample at easterly shore

S_w = Sample at westerly shore

S_m = Sample at mid-lagoon

Numerals (2.3) = Station

TABLE 7 - BENTHIC SURVEY

Sample Location		pH	Conductivity µmhos/cm	Odor	Lagoon Benthic Characteristics
1.0	S	8.95	2400	Slight	Black clay and silt; some sand; several small rocks.
2.3	S_e	8.51	2300	None	Black clay; medium sand; shell fragments
	S_m S_m (surface)	8.0	4400	No particular odor	Black very fine silt and clay; very few sand particles.
	S_w	8.9	2500	None	Black clay and silt; no sand.
3.3	S_e	8.21	1800	None	Medium brown sand fine to medium particles; some clay; several shell fragments.
	S_w	8.3	2200	None	Black clay with some sand and several small rocks.
4.3	S_e	7.75	2100	None	Medium brown sand with some clay; fine to medium sand particles.
	S_m S_w	8.4	2100	Slight odor of marine decay	Dark brown sand and clay; fine to medium sand particles; several small stones.
5.3	S_e	8.3	1900	Very slight	Brown and black clay; some sand; several small rocks.
	S_w	8.45	2200	Very slight	Brown sand with black clay and silt; large stones; many small stones.
6.3	S_e	8.2	2100	None	Black sand and clay; fine to medium particles.
	S_m S_w	8.5	1600	Slight odor of drying marine organisms and vegetation	Medium brown sand fine to medium particles; some black clay; several small rocks, piece of broken glass.
7.3	S_e	7.8	1800	None	Medium brown sand; fine to coarse particles; some black clay; small brown worm,

Continued

TABLE 8

CHEMICAL ANALYSES - BENTHIC SAMPLES

Station	2.3	3.3	4.3	5.3	6.3	7.3
Total Solids mg/l	598,000	600,000	599,000	629,000	680,000	762,000
% Organic Solids	8.0	6.7	6.7	5.2	3.9	1.3

(about 5.3 percent average) in the total solids (see Table 4). A few worms and snails were observed. However, their rarity also indicates that the benthos was not very active biologically.

Some miscellaneous litter was found in limited quantities, such as concrete rubble, bottles, cans, rubber ball, dice, fishing gear, etc. Vegetation and litter below the water line should be removed, preferably physically.

F. Survey of Shoreline Conditions

Field reconnaissance and city maps yielded data on shore plantings, drainage patterns, and locations of storm drains and sanitary sewers as sources of possible pollution. There were no direct, concentrated discharges of domestic wastes into the lagoon; however, there are three storm drains that can discharge into the lagoon.

G. Climatic Information and Tides

Tidal data was obtained from standard tide tables prepared from Federal government sources. Tidal data presented is for the Los Angeles outer harbor and is believed to be very close to that for the Del Rey area which is 20 miles up the coast. Tides will not usually affect the lagoon except during deliberate opening of the gate near the northerly end.

Weather conditions, temperature, wind and precipitation during sampling periods were recorded in the field. More extensive regional data was obtained from the U.S. Weather Bureau Station at Los Angeles International Airport.

Weather is one of the factors influencing algal blooms, which proliferate more readily during the warm summer weather, and the growth of vegetation. However, no direct correlations with temperature fluctuations existed.

H. Bibliography

Historical information on the lagoon and surrounding area was obtained from the Recreation and Parks Department, the Citizens Committee and others noted in the Reference section of this report. Available topographic and drainage maps and other information were also supplied by the City of Los Angeles authorities.

III. EVALUATIONS OF METHODS FOR MAINTAINING CLEAR WATER

To maintain clear water, to prevent algae and plant growth and eutrophication, and thus to maintain the lagoon in suitable condition for recreational uses, several methods were considered.

A. Pollution Control

The success of these methods depends on the control of external sources of pollution. Such control includes:

1. Eliminating vegetation below the high tide water level.

2. Preventing storm and irrigation drainage from entering the lagoon.

3. Controlling pollution by users of the lagoon (enforcing use of trash receptables and restrooms).

4. Letting Ballona Creek water into the lagoon only when it is reasonably clear and free of pollution, thus excluding the influences of red tides and storm drainage.

B. Direct Control

Seven methods are available for maintaining clear water and preventing eutrophication:

1. Dredging the lagoon bottom to remove all sediments containing organic matter.

To remove one foot of sediment by dredging is estimated to cost about $16,000, plus expenses for hauling away the dredge material. While dredging would temporarily eliminate the growth of weeds, algae could still proliferate under suitable conditions. Also, aquatic weeds will grow more readily in a deeper pond. The organic content of the sediments is very low and not strongly septic. Thus, dredging would do little to improve the bottom conditions and it would make the lagoon difficult to completely flush.

2. Providing a sterile bottom by means of a lining.

The applicable lining costs are estimated as follows:

Asphalt - $ 98,000
Gunnite - $140,000
Plastic -$ 84,000

Linings are not only relatively expensive, but can also diminish the natural appearance of the lagoon. Like dredging, they also do not affect algae proliferation.

3. Artificial Aeration.

Aerating would introduce additional oxygen, which at Del Rey Lagoon is already plentiful and would also provide upward currents to prevent stratification and retard the deposition of sediments. Turbulence inhibits the growth of some organisms and may control algae blooms. This method is feasible and is used successfully at many lakes, such as Lake Casitas near Ventura.

4. Periodically flushing the lagoon by drainage and refilling with fresh ocean water.

The benefits are twofold: First, draining the lagoon removes accumulated nutrients which enter in spite of efforts to minimize them. Irrigation, storm drainage, dead algae, fish, animal droppings, etc. inevitably add to the nutrients in the lagoon. Flushing removes these nutrients.

Second, refilling the lagoon with clean ocean water can maintain the salinity at a level in which brackish water weeds cannot grow. Although evaporation tends to increase the salinity, fresh water inflow from irrigation and storm drainage provides dilution. Even during some summer months the lagoon salinity was found to be only 85 percent of normal ocean water.

An automatic, periodic flushing system would consist of a motor, gears, level switch, cam-operated controller, timer, and related circuitry. A preliminary estimate of the required hardware plus modifications as needed and installation comes to about $7000.

Flushing must not take place during conditions of red tide or other pollution in the Ballona Creek intake, but only when the ocean water is of better quality than the lagoon water. A schedule of inspections would assure this.

5. Continuously circulating clean ocean water by mechanical pumping has the same functions and benefits as periodic flushing.

It would be possible to continuously keep the lagoon full, clear and useable. However, it is much more expensive to pump and filter the lagoon waters than to flush them periodically. The installation of the necessary pipes, pumps and valves would cost about $150,000. In addition there would be regular operation and maintenance costs.

6. Chemically treating to eliminate algae and weeds.

The degree of toxicity of herbicides to other species would have to be established to satisfy the State Department of Fish and Game of their safety to the ecology. Chemicals are normally applied only as the need arises. This latter procedure in combination with periodic flushing is probably the most effective and economical method of maintaining clean water in the lagoon free of aquatic weeds and in good condition for recreational uses. Both chlorine and certain copper compounds are effective and safe algaecides.

Chlorine applied at one or two points at the bottom of the lagoon would diffuse and be effective for the entire basin volume. Its application through a commercial feeder is less cumbersome than spreading chemicals from a boat. However, the initial equipment is more costly. A chlorinator station installation would cost about $10,000. Experience at the lagoon indicates that algae can be eliminated with at least two applications of 2 to 4 gallons of Cutrine per acre, and that weeds can be destroyed with an application of 60 lbs. of Karmex per acre. Karmex treatment is necessary only yearly or possibly at 6-month intervals. Cutrine may have to be applied more frequently. Two applications of Cutrine would cost about $800 (material only); a single application of Karmex costs about $920 (material only). The Cutrine cost may be greatly reduced by the use of Citric Acid and Copper Sulfate if they are found to be satisfactory substitutes.

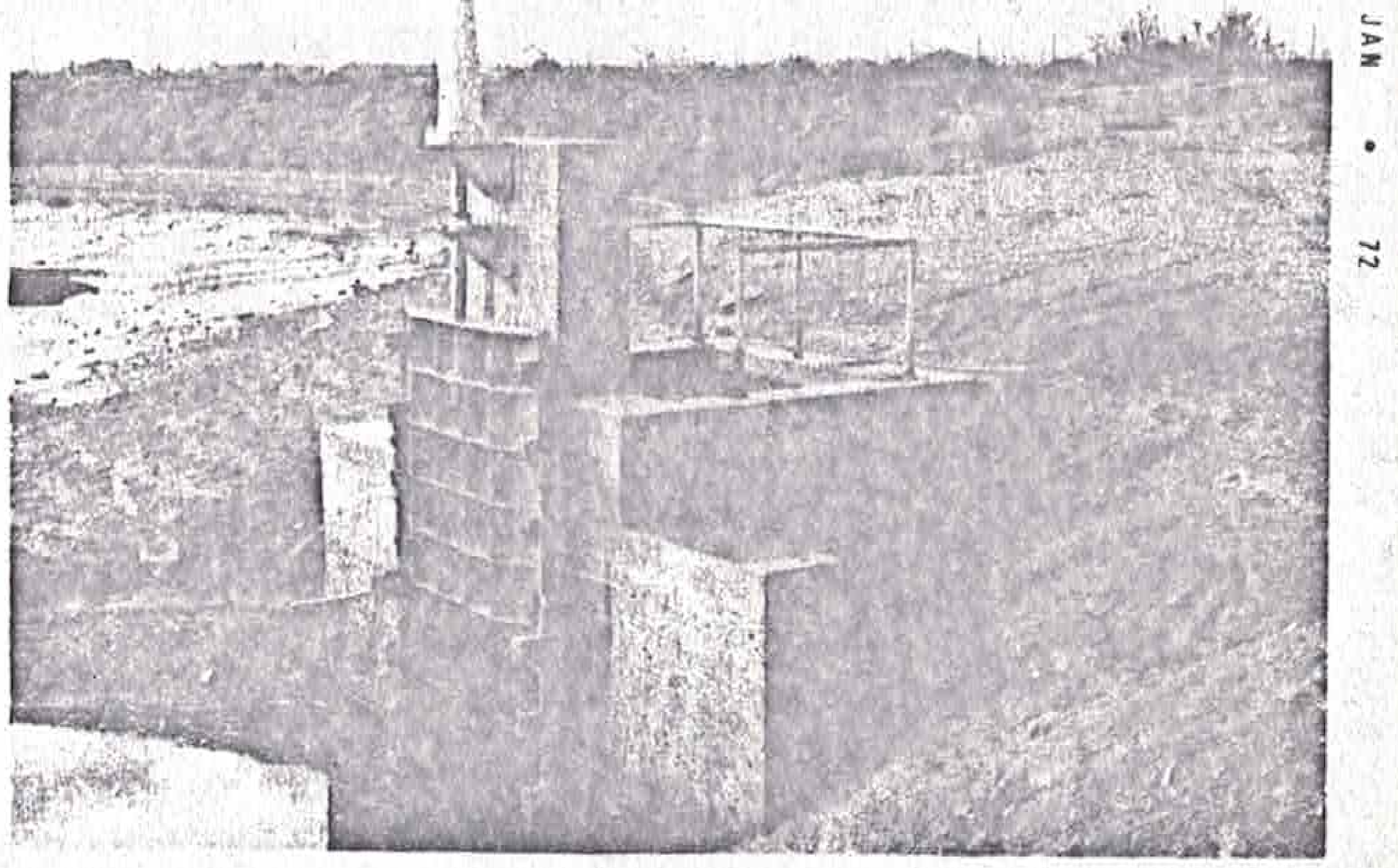
7. Minimizing eutrophication by maintaining a good biological balance.

This, however, requires a complete food chain including aquatic bottom vegetation and algae. Therefore, this method is probably not suitable for the Del Rey Lagoon, where an aquatic weed and algae free, clear water is desired.

1. Southerly End of Lagoon -
Picnic and Recreational Area

2. Northerly End of Lagoon -
Flushing Gate

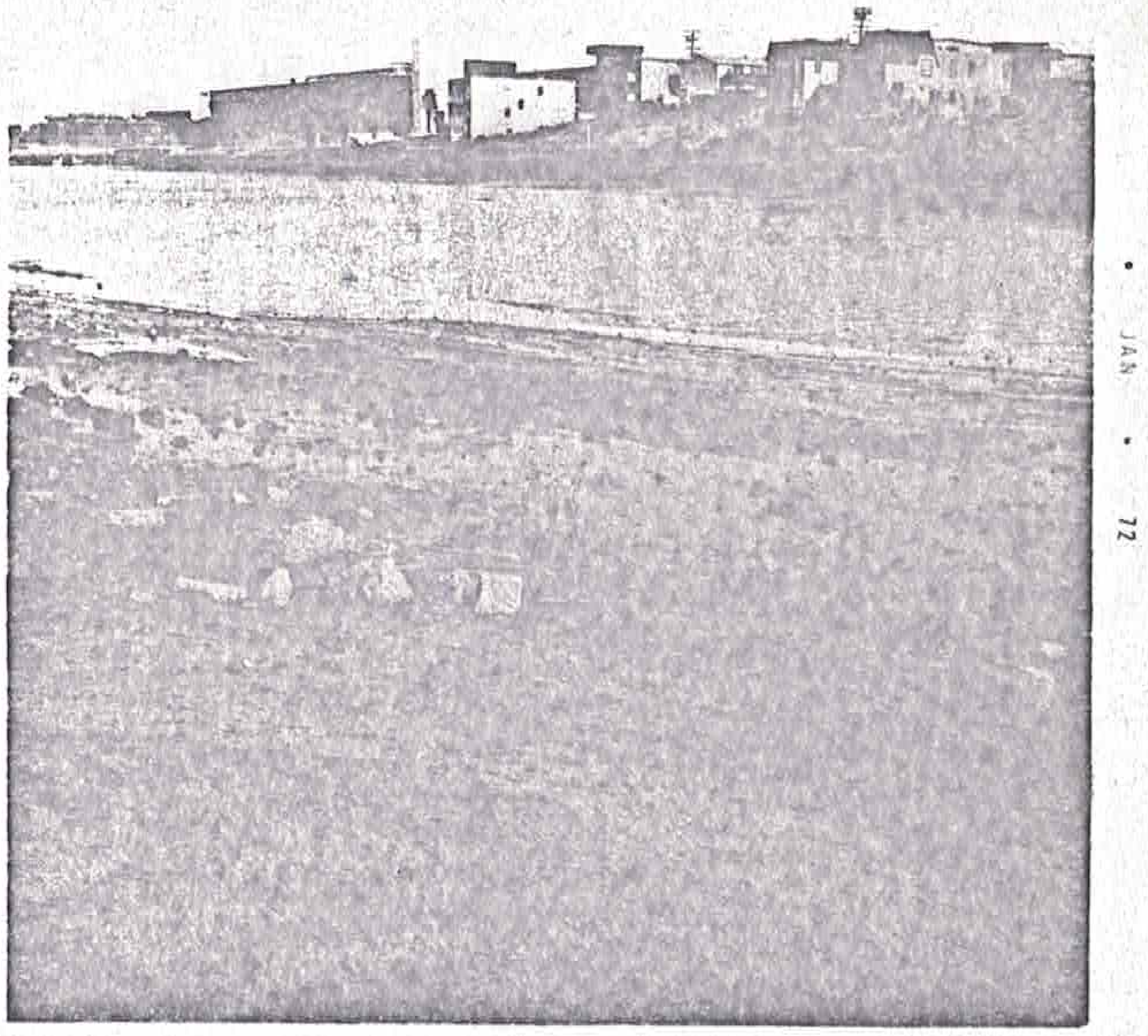
3. Closeup of Flushing Gate Structure

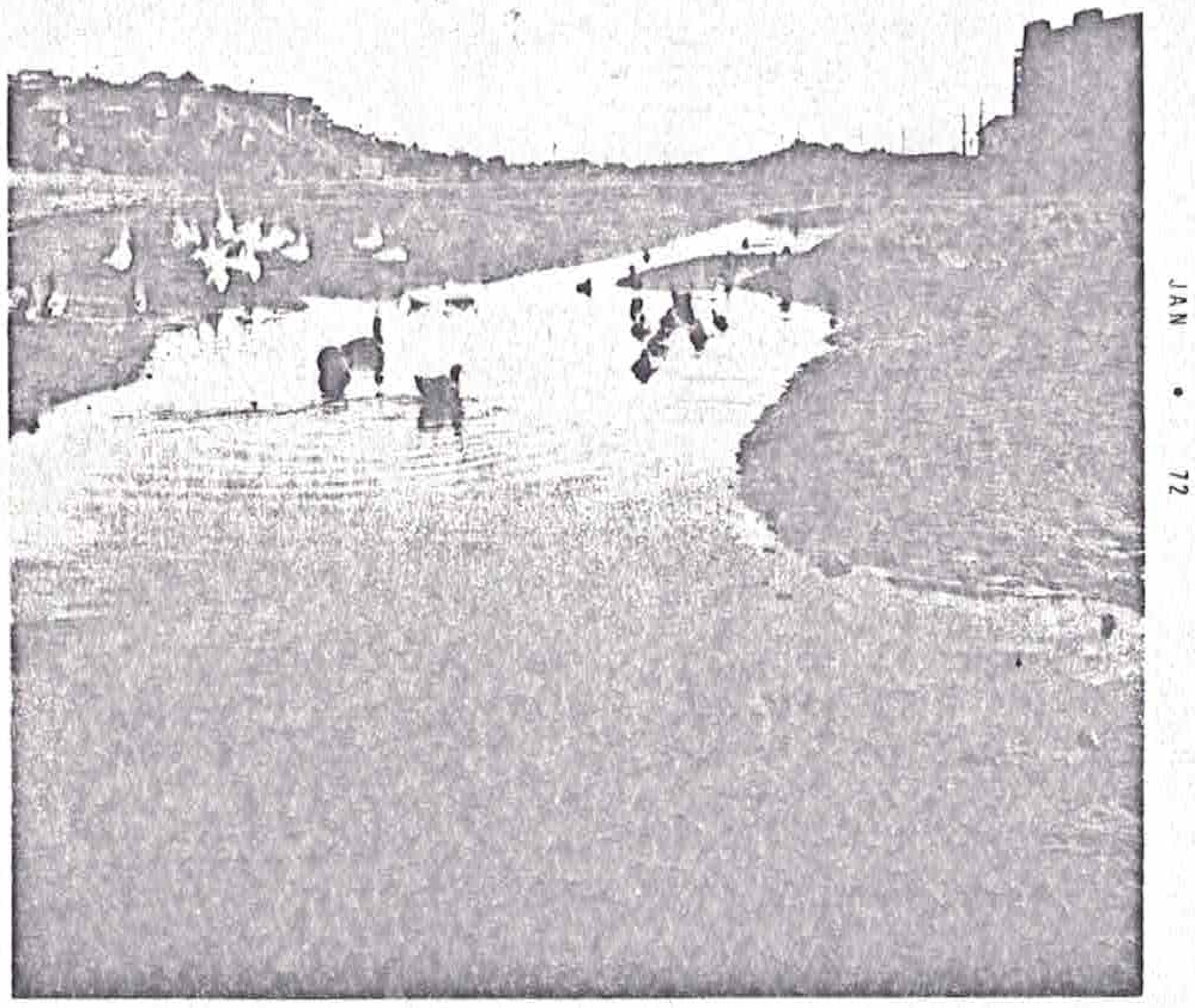


4. Westerly Shore

PHOTOGRAPHS
3 AND 4

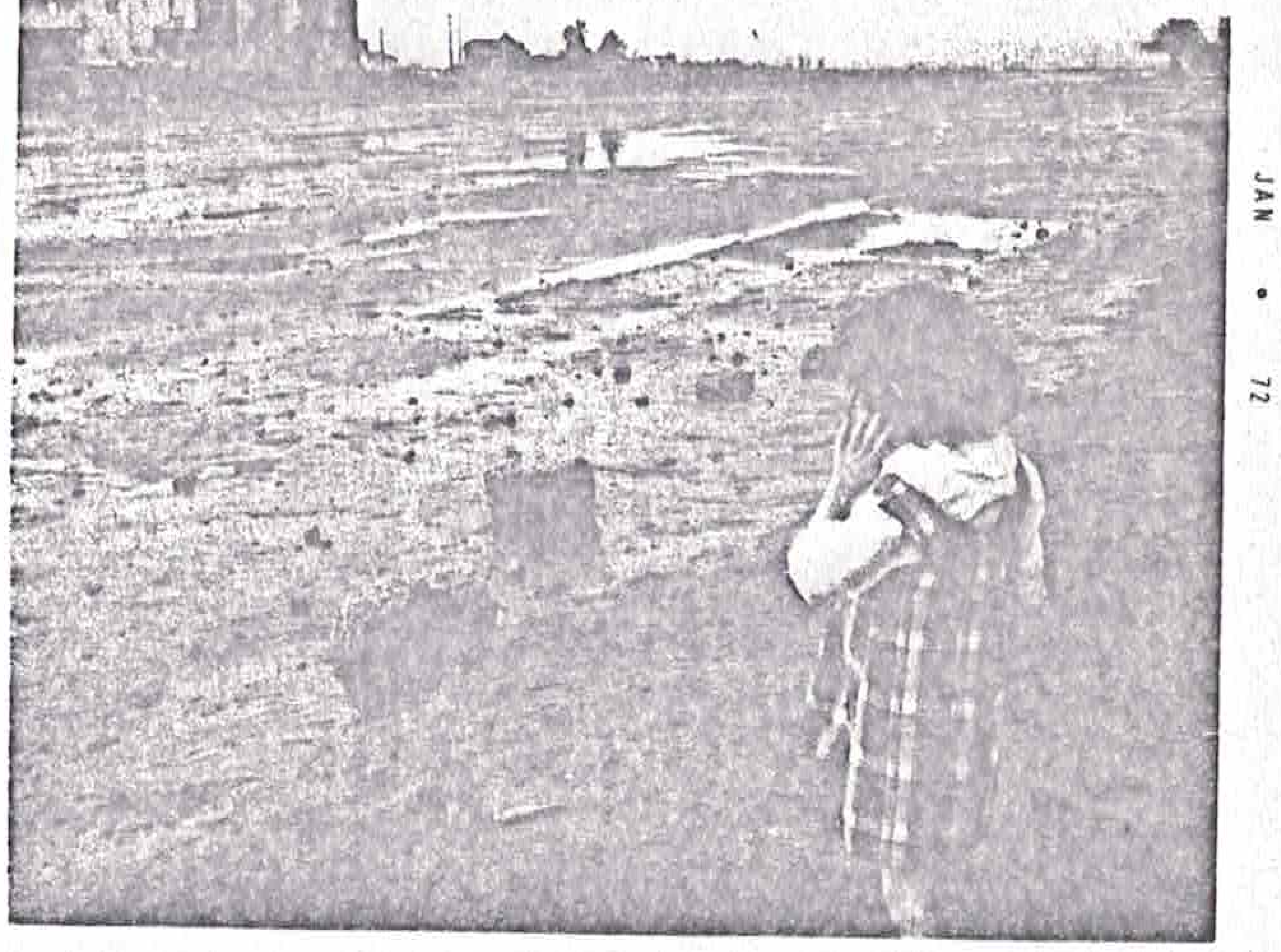
5. View from Easterly to Westerly Shore

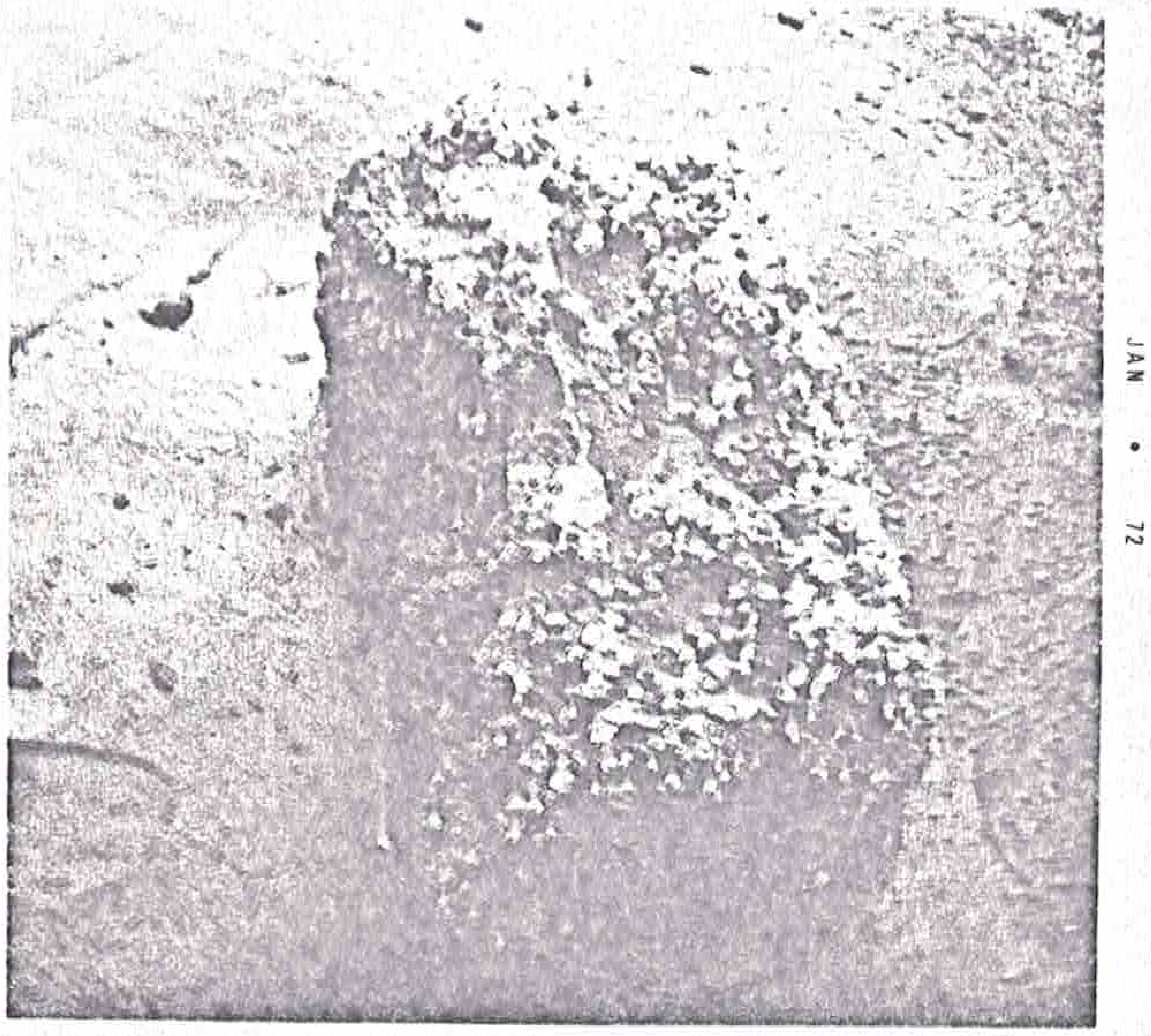




6. Bird Life

7. Empty Lagoon with Some Large Rocks





8. Rock Covered with Marine Growths